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Concepts and Practice Using Stochastic Programs for Determining Reserve Requirements

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Outline

- Simple Energy & Reserve Dispatch
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  - Model Parameters
  - Local Reserve Requirements
- WECC Model Benchmarking
  - Project Overview
  - Reserve Determination Methods Survey
  - California LTPP 2012 Model
  - Benchmark Analysis
  - Project Status
- Questions and Discussions

Simple Energy & Reserve Dispatch

Purpose

Model Parameters

Local Reserve Requirements

Purpose

- Simple Transparent Example
- Analyze LF Procurement
- Includes Unit Commitment Decisions
- Shows Impacts of Stage-1 Decisions

Model Parameters

Generation

Name	Area	Maximum Dispatch	Minimum Dispatch	Energy Cost	Cold Start Cost
GenC	PGE_VLY	200 MW	ε MW	$10 /MWh	$(2ε)
GenE	SCE	50+ε MW	ε MW	$40 /MWh	$(3ε)

Net Load

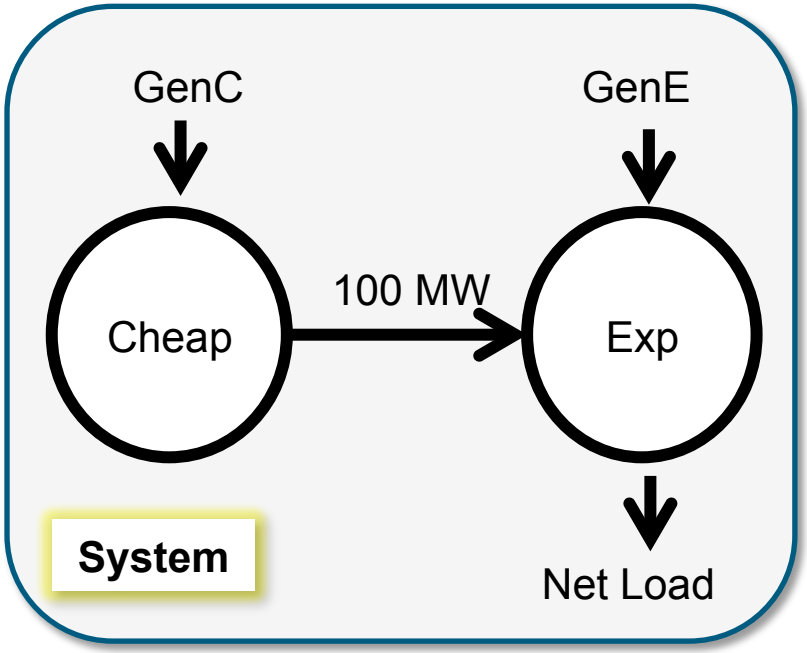
Scenario	Net Load
High	150 MW
Expected	100 MW
Low	50 MW

Sys Reserve

Model	LFU
Determ	50 MW
Stoch	0 MW

Network

Source	Sink	Capacity
Cheap	Expensive	100+ε MW
Expensive	Cheap	100+ε MW



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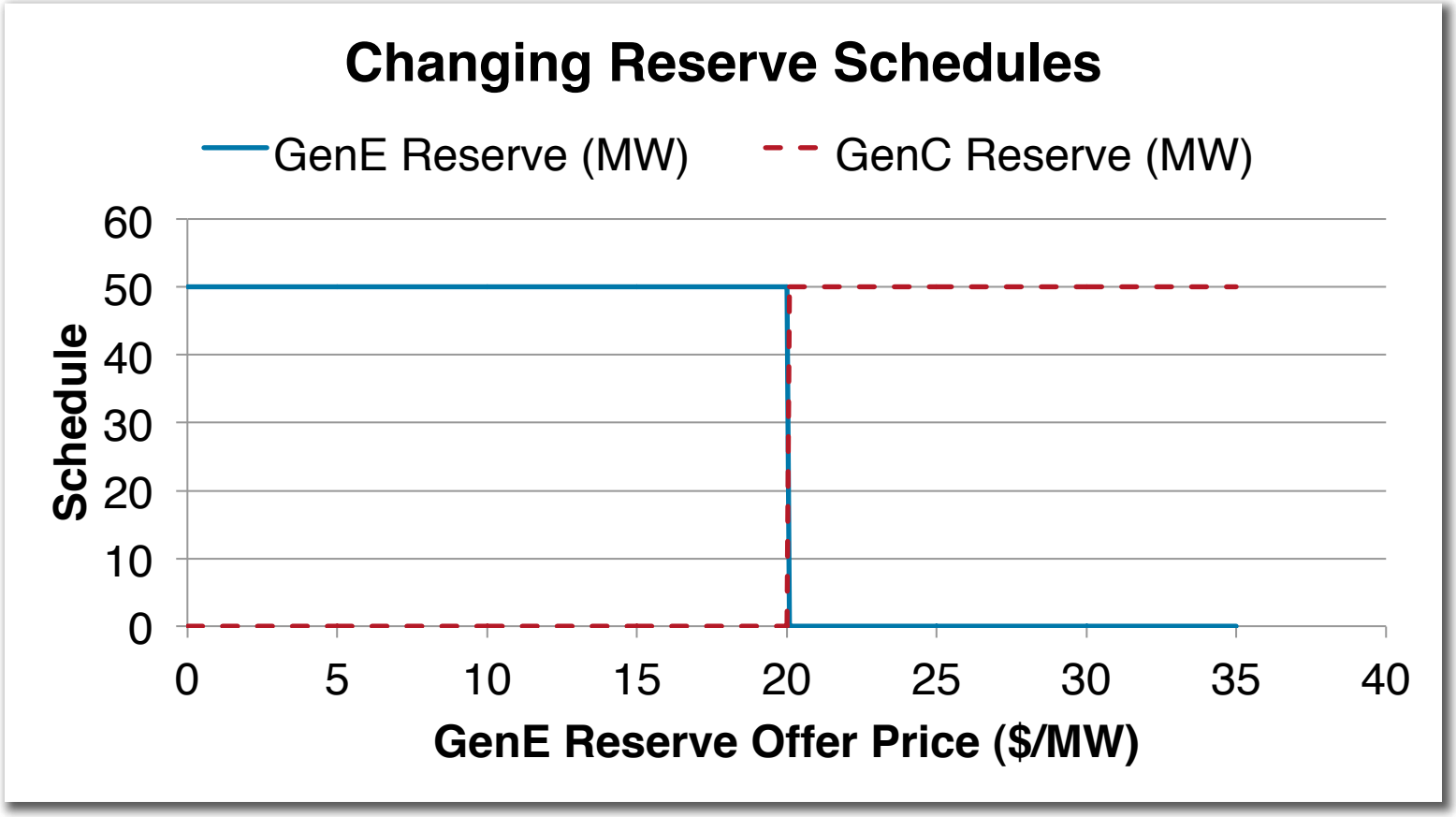
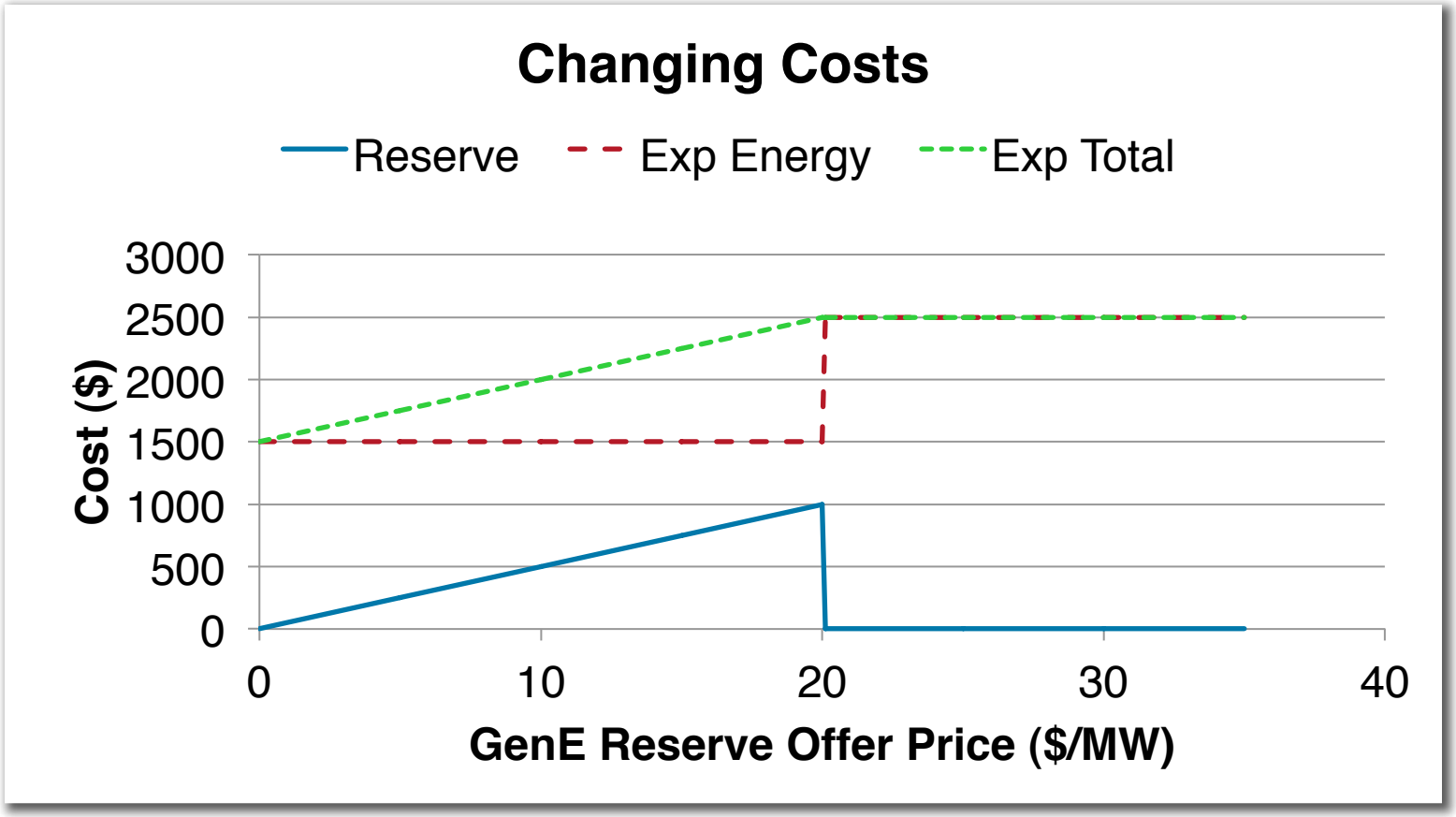
Local Reserve Requirement

- Raise cost Gen E reserve



Local Reserve Requirement

- Raise cost of Gen E reserve



Conclusions

- Myopia can lead to unplanned consequences
- Stochastic programs foresee and plan for alternatives
- Two treatments for Reserve
  - Implicit – Maximum upward change in Energy relative to current operating schedule
  - Explicit – Maximum upward change in Energy across scenarios relative to Reference Scenario
- Sufficient local reserve?
  - Yes, but economically determined
  - Requires unit commitment with foresight (must run?)

WECC Model Benchmarking

Project Overview

Reserve Determination Methods Survey

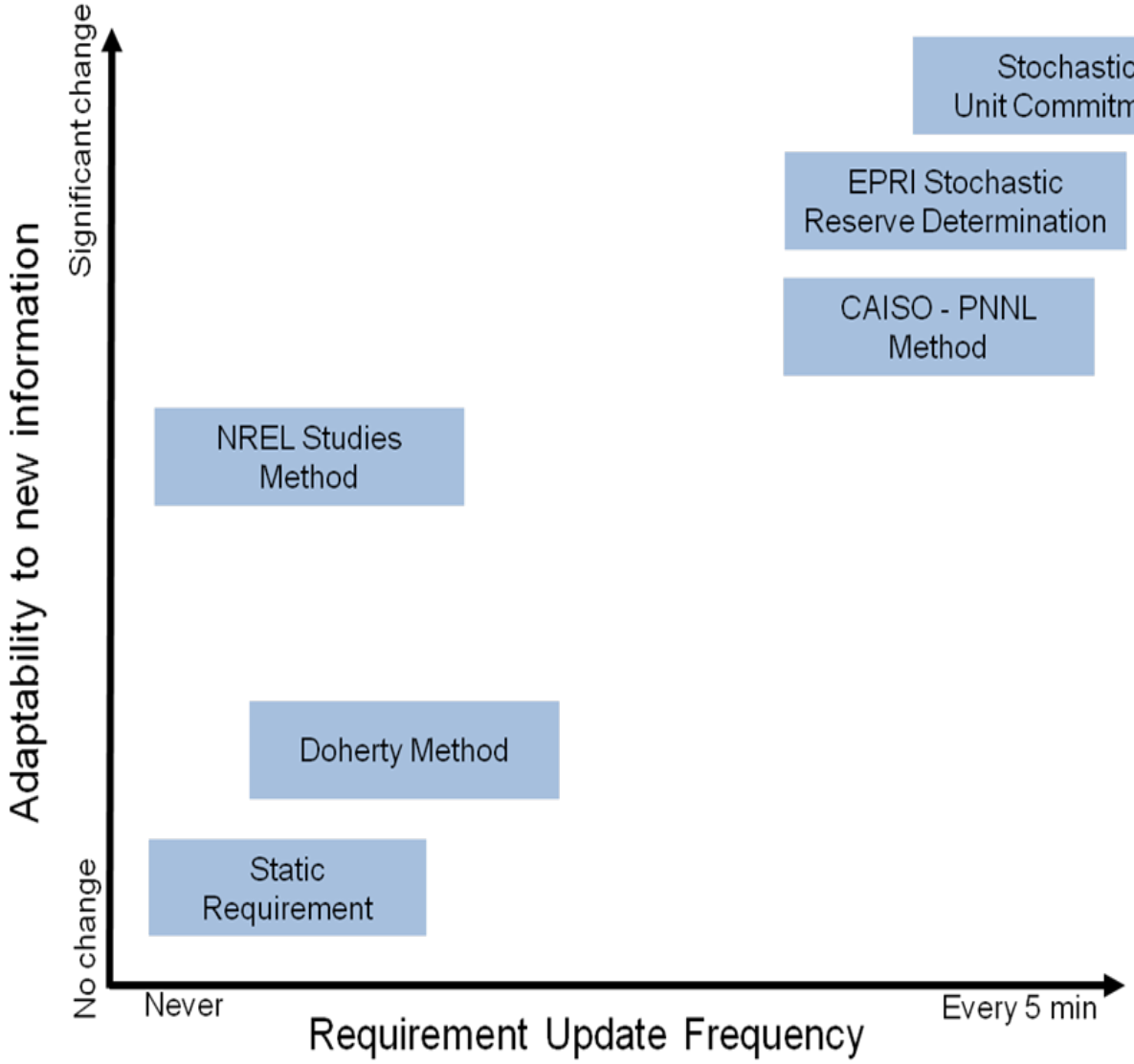
California LTPP 2012 Model

Benchmark Analysis

Project Status

WECC Model Benchmarking

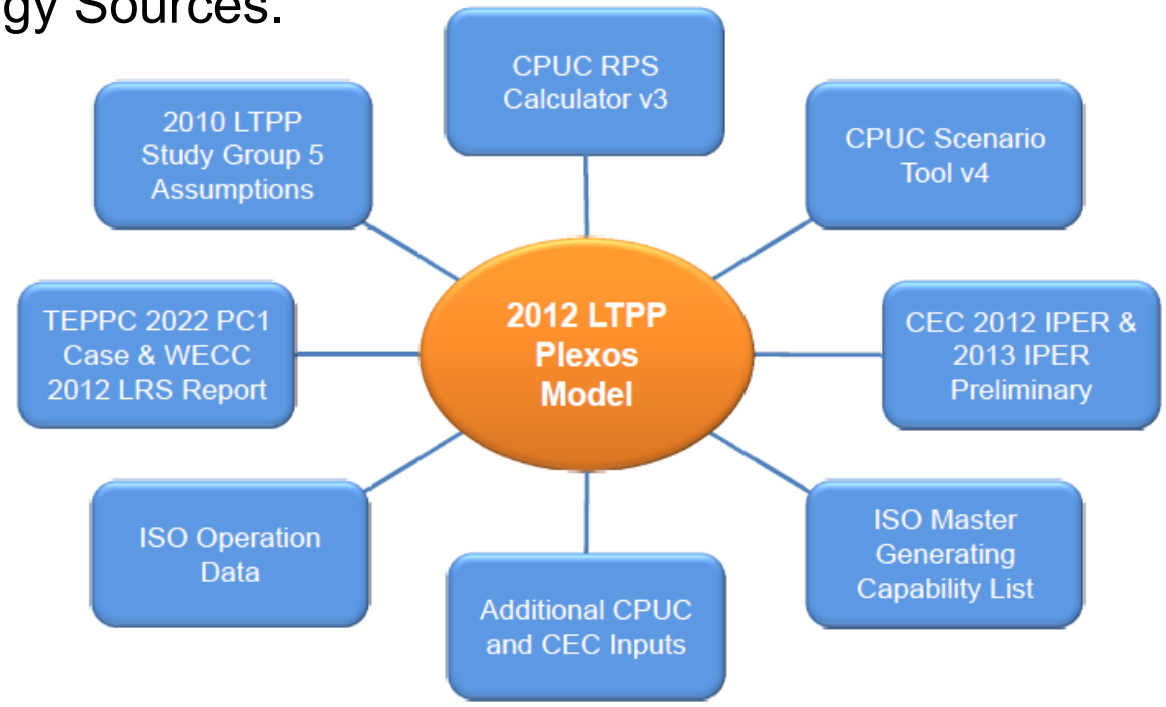
Reserve Determination Methods Survey



- Identify current practices and research being done
- Multiple manners to include forecast errors:
  - Static versus dynamic
  - Forecasted versus historical

WECC Model Benchmarking
California 2012 LTPP Model

- CAISO conducted their operational flexibility study using a PLEXOS production cost simulation model.
- Multiple data sources are combined to better represent the future of California Energy Sources.



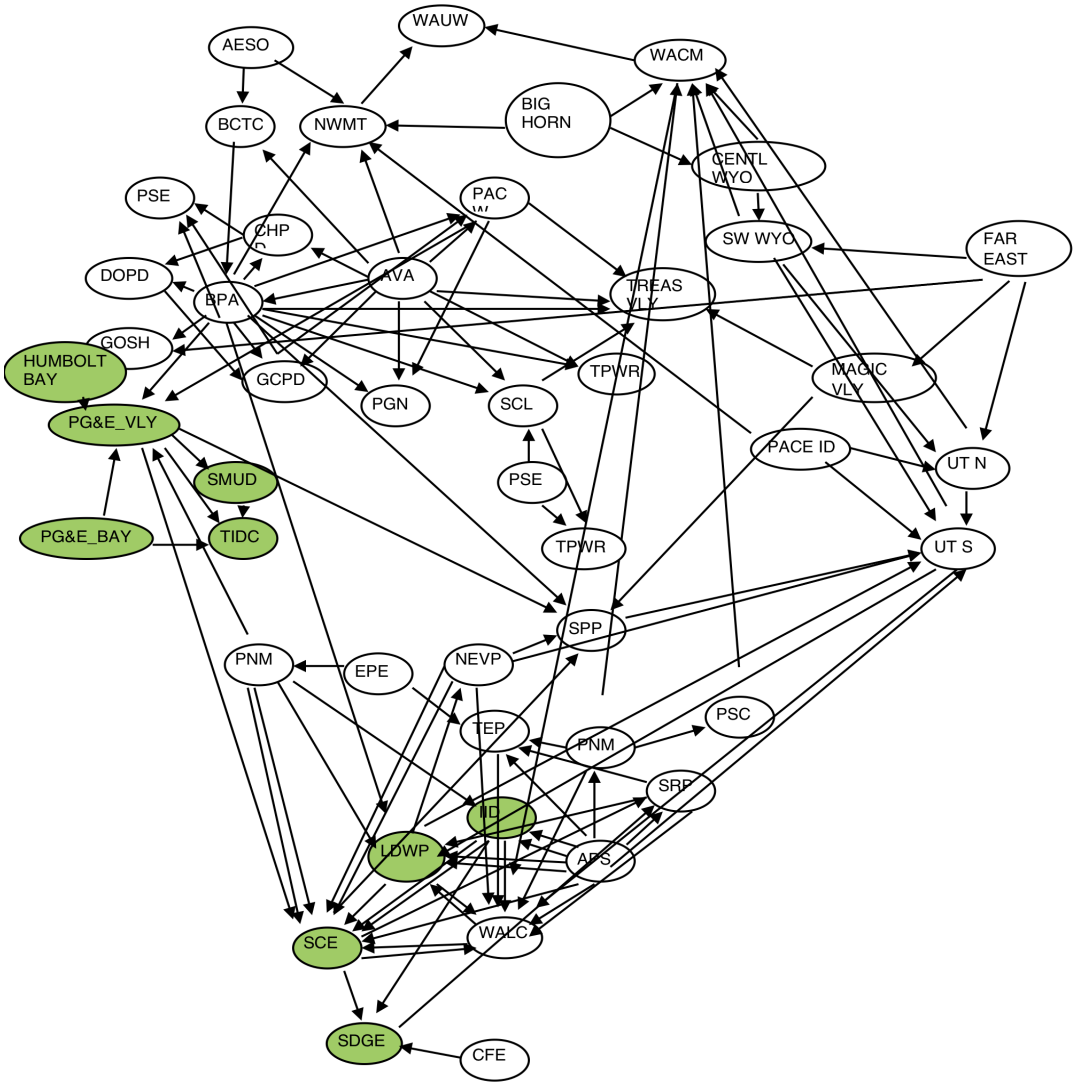
Source: 2012 LTPP Advisory Team Call

WECC Model Benchmarking

CAISO LTPP Network Model

Week of July 19, 2022

- 28 Areas in Western Interconnection
- 160 transmission lines
- Peak Load 105 GW
- 1,200 Resources
  - Unit commitment
  - 5 reserve types
- CAISO study using PLEXOS as a benchmark



WECC Model Benchmarking

Benchmark Analysis

Assumptions

- All forecasts had no error (perfect foresight / deterministic)
- Fixed Day Ahead unit commitment (based on PLEXOS)
- Fixed hydro, storage, & renewable production schedules
- Fixed hydro & renewable transmission schedules for out of state resources

Benchmark Analysis

1. Single bus network
2. Unconstrained network
3. Constrained network

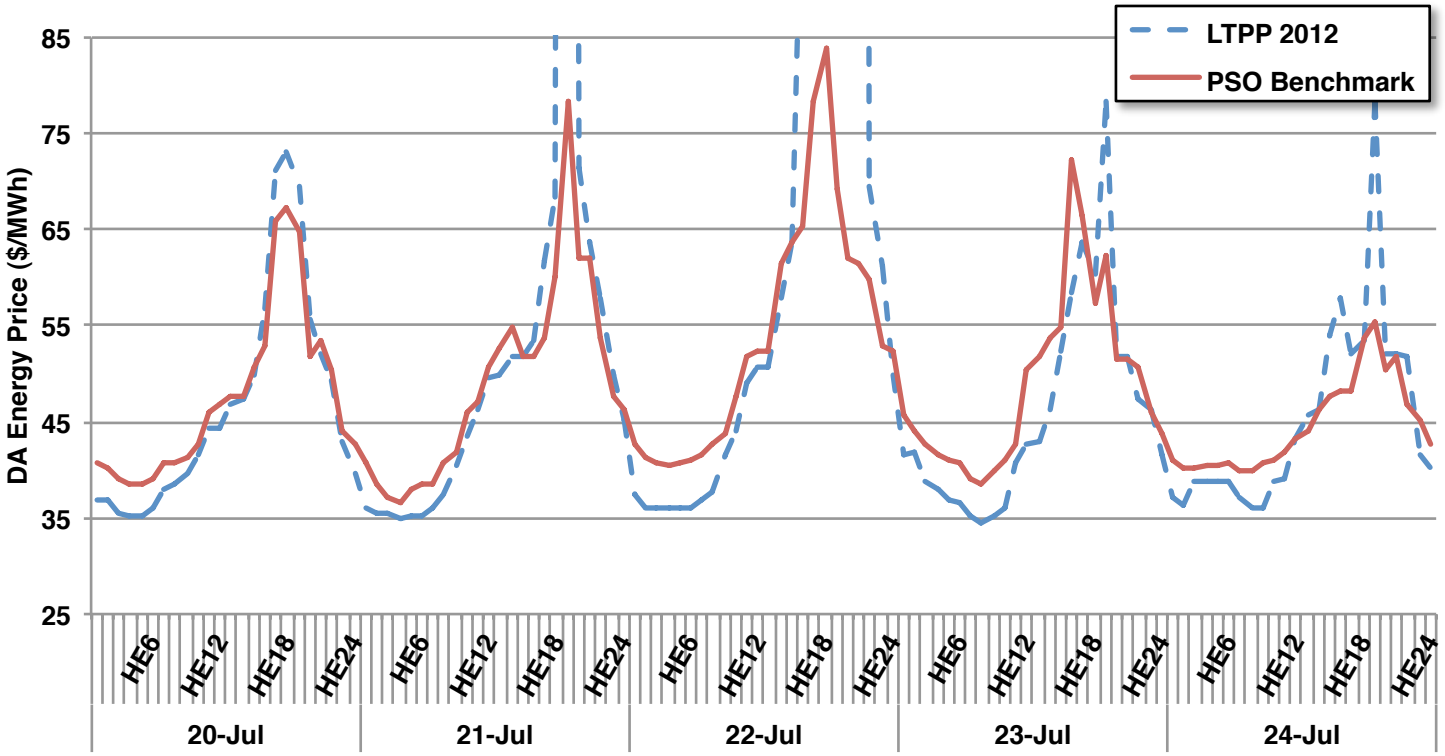
Variability Analysis

- Multi-cycle process on constrained network

WECC Model Benchmarking

Benchmark Analysis – DA Energy Prices

- Day-Ahead Energy Prices for a Constrained Western Interconnection Network Model



Energy / reserve shortages and congestion cause price spikes

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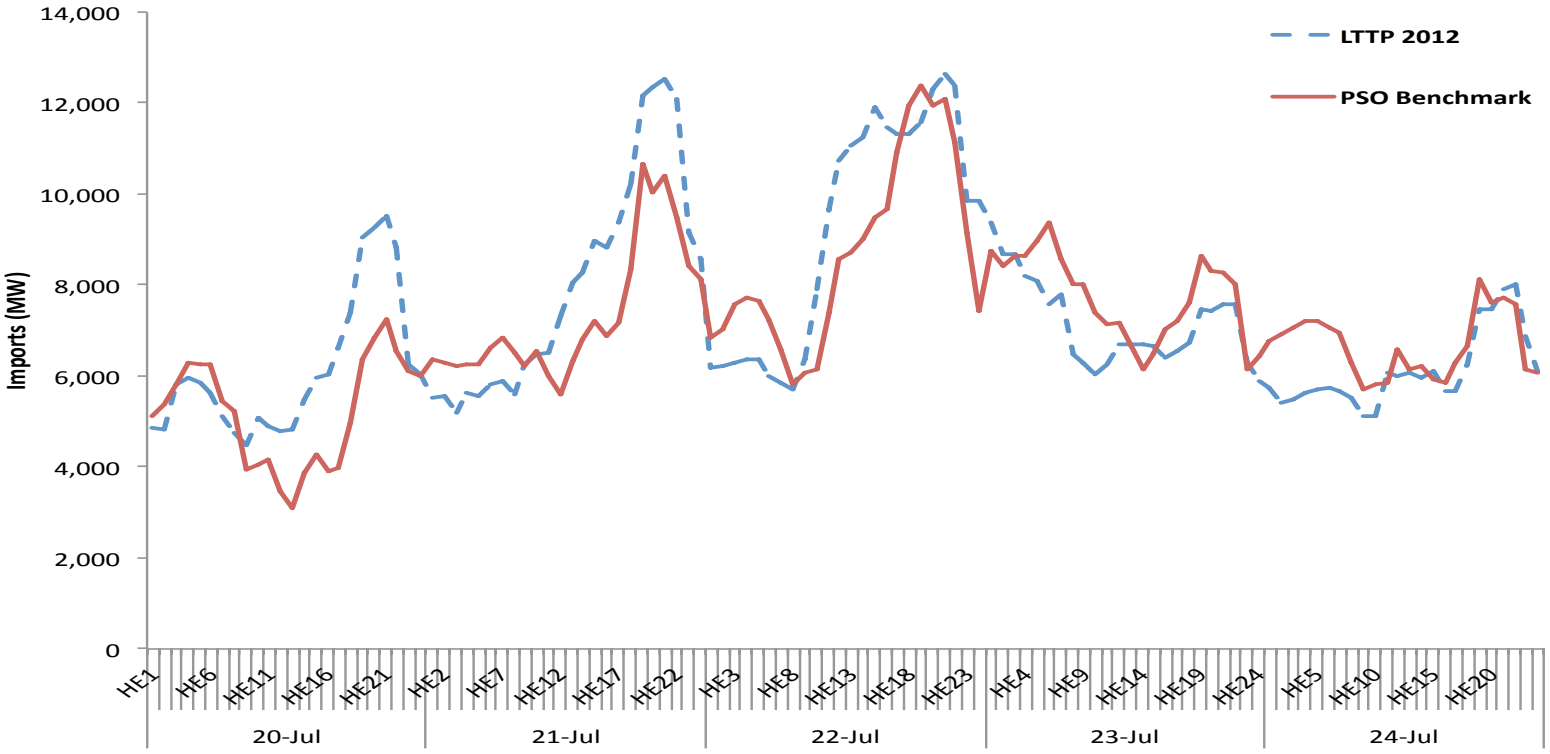
WECC Model Benchmarking

Benchmark Analysis – CA Energy Imports

- Day-Ahead CA Area Energy Imports over a Constrained Network



Magnitudes of flow are similar

WECC Model Benchmarking

Project Status

Deterministic Multi-Cycle

Perfect Foresight Case

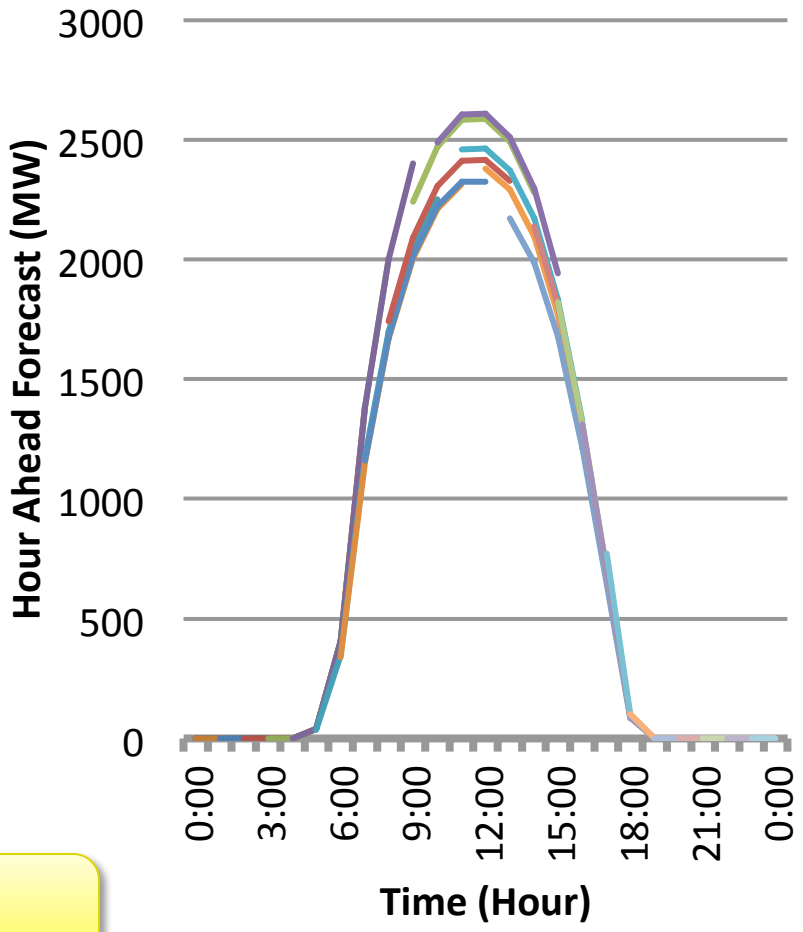
- Runs completed
- All previous violations abated

Imperfect Foresight Case

- Forecasts developed for California PV
- DA forecasts based on mean production for month
- HA / ID forecasts based on persistence forecasts

Value: Ability to value reserve when realistic uncertainty is included.

Forecast Development



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Questions & Discussion

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Together…Shaping the Future of Electricity

WECC Model Benchmarking
Project Overview

Long-Term Research Goal and Timeline:

- LT R&D Goal: Integrate Stochastic Optimal Power Flow (STOPF) applications into a variety of scheduling and EMS applications
- Expected Timeline: 2014/2015

2013 R&D Contribution/Goal:

- Specific 2013 Goals: Complete large-scale WECC case study. Begin case study with **National Grid UK**
- 2013 Value Proposition: Provides a technique and tool for setting reserve procurements under uncertainties of new resource types
- 2013 Deliverable: Technical report

Perfect Foresight Deterministic Results

Commitment Decisions	Settlement Decisions
• Unit On/Off • Reserve Schedule	• Energy Schedule • Reserve Schedule

	Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	0 MW	50 MW	50 MW	0 MW
E{Net Load}	50 MW	0 MW	100 MW	100 MW	0 MW
High Net Load	50 MW	0 MW	100 MW	100 MW	50 MW

- Deterministic modeling foresees each Net Load scenario
  - Commitment decisions vary across scenarios
- Flow is from Cheap to Expensive
- GenE does not provide LFU reserve, because it is not committed in Low and Expected scenarios

Myopic Deterministic Results

Commitment Decisions	Settlement Decisions
• Unit On/Off • Reserve Schedule	• Energy Schedule • Reserve Schedule

	Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	0 MW	50 MW	50 MW	0 MW
E{Net Load}	50 MW	0 MW	100 MW	100 MW	0 MW
High Net Load	50 MW	0 MW	100 MW	100 MW	0 MW

- Deterministic modeling foresees expected scenario
  - Commitment decisions do not vary across scenarios
- Flow is from Cheap to Expensive

High Net Load scenario has 50 MW energy violation

Stochastic Program Results

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off	• Energy Schedule

	Implicit Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	100 MW	50 MW	50 MW	50 MW	0 MW
E{Net Load}	100 MW	50 MW	100 MW	100 MW	0 MW
High Net Load	100 MW	50 MW	100 MW	100 MW	50 MW

- Off-line analysis… No actual commitment or settlement
- Both units have 50 MW implicit reserve… *Ambiguous need*
- Flow is from Cheap to Expensive
- Stochastic modeling has foresight for commitment decisions
  - High Net Load scenario is feasible, because GenE is On

LFU may be procured in either location… or none

Stochastic Program Results
Accounting "Reserve Need"

Define Reserve Need as "Maximum upward change in Energy across scenarios relative to Reference Scenario"

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off • Reserve Need	• Energy Schedule

	Reserve Need wrt E{}		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow ➔**	**GenE**
Low Net Load	0 MW	50 MW	50 MW	50 MW	0 MW
E{Net Load}	0 MW	50 MW	100 MW	100 MW	0 MW
High Net Load	0 MW	50 MW	100 MW	100 MW	50 MW

- Reserve Need is 50 MW

How much reserve is really needed from GenE?

Stochastic Program Results
Accounting "Reserve Need"

Assume reserve is not available (N/A) at GenE

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off • Reserve Need	• Energy Schedule

	Reserve Need wrt E{}		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	N/A	0 MW	0 MW	50 MW
E{Net Load}	50 MW	N/A	50 MW	50 MW	50 MW
High Net Load	50 MW	N/A	100 MW	100 MW	50 MW

- Reserve Need is 50 MW
  - GenE does not really need to provide reserve!

How can we define reserve need?